INCUBATOR


BACKGROUND OF THE INVENTION

Field of the Invention

5      This invention relates to an incubator which is used in
a biochemical analysis system, in which a sample such as blood
or urine is spotted onto a dry analysis element and, for instance,
the concentration of a specific biochemical component contained
in the sample is detected, to keep the dry analysis element
10    at a constant temperature in order to measure change of the
optical density.

Description of the Related Art

Recently, there has been put into practice a colorimetric
dry (dry-to-the touch) analysis element with which the content
15    of a specific biochemical component or a specific solid component
contained in a sample liquid can be quantitatively analyzed
by simply spotting a droplet of the sample liquid.  Since being
capable of analyzing samples easily and quickly, the biochemical
analysis systems using such dry analysis elements are suitably
20    used in medical institutions, laboratories and the like.

When quantitatively analyzing the chemical components
or the like contained in a sample liquid using such a colorimetric
dry analysis element, a droplet of the sample liquid is spotted
on the analysis element, and the analysis element is held at
25    a constant temperature for a predetermined time in an incubator
so that a coloring reaction (pigment forming reaction) occurs,

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and the optical density of the color formed by the coloring reaction is optically measured. That is, measuring light containing a wavelength which is pre-selected according to the combination of the component to be analyzed and the reagent contained in the analysis element is projected onto the analysis element and the optical density of the analysis element is measured. Then the concentration of the component to be analyzed is determined on the basis of the optical density according to a calibration curve representing the relation between the concentration of the specific biochemical component and the optical density.

When the distance between the dry analysis element and the light measuring head (a head for projecting said measuring light onto the dry analysis element and receives light from the dry analysis element bearing thereon the optical density of the dry analysis element fluctuates, there can be produced measuring errors since the light measuring head has own optimal measuring distance due to its light measuring sensitivity properties as will be described later in conjunction with Figure 4. In order to accurately measure the concentration of a specific component in the sample, it is necessary to detect even a slight coloring reaction and it is required for the colorimetry to be carried out at a high accuracy. Accordingly, it is important to keep constant the distance between the dry analysis element and the light measuring head.

In Japanese Patent Publication No. 5(1993)-72976, the

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optical components of the light measuring head are positioned where the output of the light measuring head is maximized, so that the influence of variation of the distance on the light measuring sensitivity is minimized.

5    In U.S. Patent No. 5,037,613, there is disclosed a structure in which the lower surface of the outer periphery of the incubator rotor, which is rotated with dry analysis elements spotted with the samples accommodated therein, is supported by a sliding support so that the rotational displacement of the incubator rotor is suppressed and the distance between the light measuring head and each of the dry analysis elements arranged along the outer periphery of the incubator rotor is held constant.

    However, the approach disclosed in the aforesaid Japanese patent publication is disadvantageous in that though fluctuation of the distance can be held in an acceptable range where the influence of variation of the distance on the light measuring sensitivity can be suppressed by the arrangement of the optical components so long as the diameter of the incubator rotor is small and the rotational displacement of the incubator rotor is small, fluctuation of the distance becomes too large for the optical components to suppress the influence of variation of the distance on the light measuring sensitivity in an acceptable range when the number of the dry analysis elements to be accommodated in the incubator increases and the diameter of the incubator rotor increases. An attempt to limit the

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rotational displacement of a large incubator rotor increases requirement on processing accuracy and fabricating accuracy of the components of the incubator rotor, thereby adding to the manufacturing cost of the incubator.

5      The approach disclosed in the United states patent is disadvantageous in that as the sliding support wears, the rotational displacement of the incubator rotor increases and the incubator rotor drive mechanism can become unstable due to nonuniform load and wear of the sliding support will produce dust.

Displacement in height of the incubator rotor relative to the measuring head during rotation of the incubator rotor is generated by strain generated when forming the rotor and/or strain generated when mounting the rotor on the rotating shaft. Accordingly, the distance between the measuring head and each of the element chambers arranged along the outer periphery of the incubator rotor when the element chamber is brought to a predetermined position, e.g., a light measuring position where the optical density of the dry analysis element is to be measured, is constant for each element chamber but differs from chamber to chamber. As the difference in the distance between the measuring head and the element chambers increases, variation in the measured value for a given optical density becomes larger.

As disclosed, for instance, in Japanese Unexamined Patent Publication No. 11(1999)-237386, there has been known an incubator provided at its center with an element discarding

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hole through which dry analysis elements after measurement are discarded by pushing the dry analysis elements further inward by the element transfer member which pushes the dry analysis elements into the element chambers of the incubator. This structure is advantageous in that the dry analysis elements can be easily discarded with the transfer mechanism of a simple structure.

However, as the number of the dry analysis elements to be accommodated in the incubator increases and the diameter of the incubator rotor increases, the diameter of the discarding hole must be large in order to discard the dry analysis elements in all the element chambers by a limited stroke of the element transfer member. When the diameter of the discarding hole is enlarged and the diameter of the rotating shaft of the incubator rotor is increased, the diameter of the bearing member for supporting the rotating shaft must be large, which adds to the manufacturing cost of the bearing member. Especially when the bearing member must support the rotating shaft of the incubator rotor so as to suppress the rotational displacement of the incubator rotor in the acceptable range as described above, the manufacturing cost of the bearing member is further increased.

On the other hand, when the diameter of the element discarding hole is reduced, the distance over which the dry analysis elements are conveyed to be discarded becomes longer, which adds to the length and stroke of the element transfer

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member and increases the overall size and weight of the apparatus.

## SUMMARY OF THE INVENTION

In view of the foregoing observations and description, the primary object of the present invention is to provide an incubator which can accurately measure the optical density of the dry analysis element in all the element chambers of the incubator without using a sliding support and can be manufactured at low cost even if it is provided with a large number of element chambers and is large in size.

Another object of the present invention is to provide an incubator which is precise in rotation and small in weight and in which the dry analysis elements can be easily discarded after measurement.

The first object of the present invention can be accomplished by an incubator comprising a rotating incubator rotor provided with a plurality of element chambers which are arranged along the outer periphery of the incubator rotor and each of which accommodates a dry analysis element spotted with a sample and incubates the dry analysis element and a light measuring means having a light measuring head which measures the optical density of the dry analysis element, wherein the improvement comprises that

the light measuring means is provided with a correction means which compensates for fluctuation in the value of the optical density of the dry analysis element in each of the element

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chambers as measured by the light measuring head generated due to fluctuation in the distance between the light measuring head and the element chamber on the basis of a correction value which has been stored in the correction means element chamber by

5    element chamber.

It is preferred that the correction means sets the correction value for each element chamber by inserting a calibration element whose optical density is known into each of the element chambers of the incubator rotor, measuring the

10   optical density of the calibration element with the light measuring head and determining the correction value for the element chamber on the basis of the difference between the known optical density of the calibration element and the measured optical density of the same.

15   In the incubator of this invention, since the measured value of the optical density of the dry analysis element in each element chamber is corrected on the basis of a correction value which is set according to the position of the element chamber, i.e., the distance between the light measuring head

20   and the element chamber in which the dry analysis element is accommodated, the optical density can be accurately measured for each element chamber even if the distance between the light measuring head and each of the element chambers of the incubator fluctuates chamber to chamber. Accordingly, the incubator

25   rotor need not be so precisely manufactured and the sliding support becomes unnecessary, whereby the incubator can be easily

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manufactured at low cost and the durability of the incubator is increased.

When the correction means sets the correction value for each element chamber by inserting a calibration element whose optical density is known into each of the element chambers of the incubator rotor, measuring the optical density of the calibration element with the light measuring head and determining the correction value for the element chamber on the basis of the difference between the known optical density of the calibration element and the measured optical density of the same, setting of the correction value is facilitated.

That is, though the incubator rotors rotate in different ways according to the processing accuracy and the like and the distance between the light measuring head and each of the element chambers in the measuring position to which the element chambers are brought in sequence as the incubator rotor rotates differs element chamber to element chamber, the optical density can be accurately measured for each element chamber irrespective of fluctuation in distance between the light measuring head and the element chamber by correcting the measured value for each element chamber on the basis of a correction value determined for each element chamber according to the real distance between the light measuring head and the element chamber. The correction value for each element chamber can be easily set by reading the measurement for a calibration element whose optical density is known and determining the correction value

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on the basis of the difference between the known optical density and the measured value.

The second object of the present invention can be accomplished by an incubator comprising a rotating incubator rotor provided with a plurality of element chambers which are arranged along the outer periphery of the incubator rotor and each of which accommodates a dry analysis element spotted with a sample and incubates the dry analysis element, wherein the improvement comprises that

the incubator rotor is provided with a cone-like slant surface which is formed below the element chambers and tapers downward toward the axis of rotation of the incubator rotor, a cylindrical rotating shaft which is connected to the lower end of the slant surface and the inner space of which opens to the space defined by the cone-like slant surface so that the dry analysis element in each element chamber can be discarded outside the incubator through the space defined by the cone-like slant surface and the inner space of the cylindrical rotating shaft and a bearing member which supports the cylindrical rotating shaft for rotation about the axis of rotation of the incubator rotor.

It is preferred that the slant surface be at an angle not smaller than 30° to the horizontal so that the dry analysis element is surely slid on the slant surface toward the cylindrical rotating shaft.

In the incubator of this arrangement, the rotating shaft

need not be large in diameter even if the number of the dry
analysis elements to be accommodated in the incubator increases
and the diameter of the incubator rotor increases, and
accordingly, the bearing member may be small in diameter, whereby
5    the incubator can be manufactured at low cost.   Further, since
the dry analysis elements after measurement can be discarded
by pushing the dry analysis elements only to the slant surface,
the stroke of the element transfer member need not be enlarged
even if the number of the dry analysis elements to be accommodated
10   in the incubator increases and the diameter of the incubator
rotor increases, whereby the incubator can be small in size
and weight.

Further by virtue of the member defining the cone-like
slant surface, rigidity of the incubator rotor is increased
15   and the incubator rotor can be rigid enough though it is small
in weight, whereby wobbling of the incubator rotor can be
suppressed without use of a sliding support and the measuring
accuracy can be enhanced.

The incubator can be employed to incubate various types
20   of dry analysis element without limited to the colorimetric
dry analysis element.   For example, the incubator can be
employed to incubate electrolytic dry analysis elements for
measuring the activity of a specific ion contained in a sample
liquid.

25              BRIEF DESCRIPTION OF THE DRAWINGS
Figure 1 is a perspective view showing a biochemical

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analysis system provided with an incubator in accordance with an embodiment of the present invention,

Figure 2 is a schematic cross-sectional view showing the incubator with the cover removed,

Figure 3 is a block diagram showing the measuring mean,

Figure 4 is a view for illustrating change of the sensitivity of the light measuring head with the distance between the element chamber and the light measuring head,

Figure 5 is a view showing correction value properties, and

Figure 6 is a cross-sectional view showing an incubator in accordance with another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In Figure 1, a biochemical analysis system 1 comprises a system body 17 and a circular sample tray 2 is provided on one side of the front portion of the system body 17. A circular incubator 3 is provided on the other side of the front portion of the system body 17, and a spotting station (not shown) is provided between the sample tray 2 and the incubator 3. Further a spotting nozzle unit 5 is provided on an upper portion of the system body 17 to be movable right and left. A dry analysis element 11 held in a sample cartridge 7 is moved to the spotting station and spotted with a sample. Then the dry analysis element 11 spotted with the sample is transferred to the incubator 3. A blood filtering unit 6 for separating blood plasma from blood is provided beside the sample tray 2.

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The incubator 3 comprises an incubator rotor 30 and a measuring means 4. The incubator rotor 30 comprises lower and upper disc members 31 and 32, and a plurality of element chambers 33 in which the dry analysis elements 11 are inserted are formed between the lower and upper disc members 31 and 32 arranged along the circumference of the disc members 31 and 32 at regular intervals.

A rotating shaft 36 extends downward at the center of the lower disc member 31 and the rotating shaft 36 is supported for rotation by a bearing member 37 so that the lower disc member 31 is rotated horizontally about the rotating shaft 36. A sprocket 36s is fixed to the lower end portion of the rotating shaft 36 and in mesh with a drive gear 38a fixed to the output shaft of a drive motor 38 so that the incubator rotor 30 is rotated in the regular direction and the reverse direction by the drive motor 38.

Sliding holes 32a are formed in the upper disc member 32 to be opposed to the element chambers 33. A pressing member 34 is disposed above each element chamber 33 with its upper portion slidably received in the sliding hole 32a. The lower surface of the pressing member 34 presses downward the dry analysis element 11 inserted into the element chamber 33 and tightly closes the spotting hole of the dry analysis element 11 (through which the sample is spotted onto the element 11) to prevent evaporation thereof. The outer edge of the lower portion of the pressing member 34 is tapered so that the dry

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analysis element 11 inserted into the element chamber 33 is brought into abutment against the tapered surface to push upward the pressing member 34.

A heater 35 is provided in the upper disc member 32 to heat the dry analysis elements 11 in the element chambers 33. By controlling the heater 36, the dry analysis elements can be held at a desired constant temperature (incubated).

A light measuring window 31a is formed in the bottom of the lower disc member 31 opposed to each of the element chambers 33. A light measuring head 41 is positioned below the light measuring window 31a of the element chamber 33 stopped in a light measuring position shown in Figure 2. Though not shown, the incubator rotor 30 is covered with a cover in order to cut influence of the ambient temperature to the dry analysis elements 11 and to prevent external light from impinging upon the light measuring head 41.

The incubator rotor 30 is rotated back and forth so that the element chambers 33 are brought to the light measuring position in sequence and returned to the initial position after measurement of the optical density of each dry analysis element 11 due to the coloring reaction.

When the optical density is measured, the light measuring head 41 projects measuring light containing a wavelength which is pre-selected according to the combination of the component to be analyzed and the reagent contained in the dry analysis element 11 onto the dry analysis element 11 through the light

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measuring window 31a and measures the optical density of the
dry analysis element 11. The light measuring head 41 is mounted
on the incubator body (not shown). As the incubator rotor 30
is rotated by the drive motor 30, the distance $d$ between the
element chamber in the light measuring position and the light
measuring head 41 periodically changes since the height of the
incubator rotor 30 in the light measuring position varies
according to the angle at which the incubator rotor 30 is mounted
on the rotating shaft 36.

As shown in Figure 3, the optical density of the dry
analysis element 11 as measured by the light measuring head
41 is sent to an operating section 42 and is corrected by a
correction means 43 on the basis of a correction value which
has been stored for the position of each element chamber 33
(for the distance of each element chamber 33 from the light
measuring head 41 when the element chamber 33 is in the light
measuring position). The correction means 43 is provided with
a correcting section 44. The correcting section 44 receives
a signal from a position detecting section 45 which represents
the position of the element chamber 33 which is stopped above
the light measuring head 41 (in the light measuring position)
and reads out a correction value corresponding to the element
chamber 33 stopped above the light measuring head 41 from a
memory 46. The operating section 42 corrects the optical
density of the dry analysis element 11 in the element chamber
33 in the light measuring position on the basis of the correction

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value, thereby obtaining a true optical density of the dry analysis element 11 free from influence of fluctuation in distance.

The position detecting section 45 detects the rotational phase of the incubator rotor 30 by way of rotation of the motor 38 (e.g., by the use of a rotary encoder) and detects the element chamber 33 which is stopped in the light measuring position. Though not shown, the control section of the biochemical analysis system 1 which controls the overall operation of the system 1 is provided with a bar code reader and bar codes representing information on the item to be analyzed of the dry analysis element 11 to be inserted into each element chamber 33 is read by the bar code reader. The information on the item to be analyzed of the dry analysis element 11 to be inserted is stored together with the element chamber 33 in which the dry analysis element 11 is inserted.

The correction means 43 is further provided with a calibrating section 47 inserts a calibration element whose optical density is known into each of the element chambers 33 of the incubator rotor 30, receives the optical density of the calibration element as measured by the light measuring head 41 from the operating section 42 and writes the correction value for the element chamber determined on the basis of the difference between the known optical density of the calibration element and the measured optical density of the same in the memory 46.

The operating section 42 outputs corrected optical

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density to a concentration calculating section 48 and the concentration calculating section 48 determines the concentration of the component to be analyzed on the basis of the corrected optical density according to a calibration curve

5  49 and outputs the concentration of the component thus determined as a measured concentration.

Basic properties of the correction will be described with reference to Figures 4 and 5, hereinbelow. The sensitivity of the light measuring head 41 changes with change in distance

10  d to the dry analysis element 11 generally as shown in Figure 4. When a calibration element of a highly reflective ceramic whose optical density is known is measured, the output of the light measuring head 41 is maximized (Vo) at a point $\underline{D}$ at which the distance $\underline{d}$ is optimal, and is reduced as the distance d

15  is reduced or increased. For example, at point $\underline{a}$, where the distance d is smaller than at the point D, the output of the light measuring head 41 is reduced to V1 and at point $\underline{b}$, where the distance d is smaller than at the point D, the output of the light measuring head 41 is reduced to V2. This properties

20  changes in proportion with change of the optical density of the dry analysis element 11. On the basis of this fact, the correction value is set.

Figure 5 shows the relation between the output of the light measuring head 41 before correction and the corrected

25  optical density. In Figure 5, Ko is a line of correlation between the measured optical density Vo (the output of the light

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measuring head 41) as measured at the point D and the true optical density Eo. The correction value is set according to, for instance, correlation lines Ka and Kb (which are for the points $a$ and $b$, respectively) which are obtained by moving parallel the line Ko so that the outputs V1 and V2 of the light measuring head 41 as measured at the points a and b correspond to the true optical density Eo

That is, an output Va of the light measuring head 41 as measured at a distance from an element chamber 33 equal to that of the point $a$ is converted according to the correlation line Ka to an optical density Ea which is higher than uncorrected optical density Ea' converted according to the correlation line Ko. Similarly, an output Vb of the light measuring head 41 as measured at a distance from an element chamber 33 equal to that of the point $b$ is converted according to the correlation line Kb to an optical density Eb which is higher than uncorrected optical density Eb' converted according to the correlation line Ko.

The distance by which the correlation line Ko is moved to obtain the correlation line Ka or Kb is a function of the distance d between the light measuring head 41 and the element chamber 33 which can be represented by the rotating angle of the incubator rotor 30. Accordingly, by measuring a calibration element whose optical density is known and determining the deviation of the measured optical density from the known optical density as a distance from the optimal distance where the

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sensitivity of the light measuring head 41 is maximized, the influence on the measured value of fluctuation of the distance between the light measuring head 41 and the element chamber 33 can be compensated for.

5      For example, incubator rotors 30 have different rotational displacement properties due to, for instance, processing accuracy and the distance to the light measuring head 41 differs from element chamber to element chamber (in the light measuring position). A calibration element whose optical density is known is inserted into each of the element chambers 33 and the optical density of the calibration element in each element chamber 33 is measured while rotating the incubator rotor 30 to bring the element chambers 33 to the light measuring position in sequence. The correction value is determined for each element chamber 33 on the basis of the difference between the measured optical density and the known optical density, and the correction values for the respective element chambers 33 are stored together with the angular positions of the incubator rotor 30, i.e., the positions of the respective element chambers 33. Then the output of the light measuring head 41 is corrected (the measured optical density is corrected) on the basis of the correction value specific to the element chamber 33.

In Figure 1, the sample tray 2 comprises a turntable 21 which is rotated in opposite directions. Five sample cartridges 7 are mounted on the turntable 21 in an arcuate line. The sample

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cartridges 7 are removable separately from each other.  Each
sample cartridge 7 comprises a sample holding portion 71 which
holds a sample container 10 (a blood-collecting tube) holding
therein a sample, and an analysis element holding portion 72
5    which holds a stack of virgin dry analysis elements 11 of
different types.

Consumables are held on the other part of the upper surface
of the turntable 21 along the outer periphery.  For example,
a number of nozzle tips 21, a mixing cup 13 (a molded product
10   provided with a plurality of cup-like recesses), a diluent
container 14 and a container 15 for other purposes are held
on the turntable 21 along the outer periphery thereof.  The
consumables may be set on the sample tray 2 in the form of
cartridges like the sample cartridge 7.

15   The turntable 21 of the sample tray 2 is rotated in the
regular direction or the reverse direction by a drive mechanism
(not shown) to positions where the spotting nozzle unit 5
operates.  By controlling the angular position of the turntable
and the position of the spotting nozzle unit 5, predetermined
20   operations required to spotting the sample on the analysis
element such as mounting a nozzle tip 12, sucking a sample,
diluent or the reference liquid, and mixing the sample and the
diluent are carried out.

An element transfer means (not shown) which transfers
25   the dry analysis element 11 is provided at the central portion
of the sample tray 2.  The element transfer means comprises

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an element transfer member (an insertion lever) which is slid back and forth in a radial direction of the sample tray 2 by a drive mechanism (not shown). The element transfer means causes the element transfer member to push a dry analysis element

5    11 out of a sample cartridge 7 into the spotting station, to push the element 11 spotted with the sample into the incubator 3, and to further push the element 11 toward the center of the incubator 3 after measurement to discard the element 11. The element transfer means controls the drive mechanism for the

10   turntable 21 to bring the sample cartridges 7 to the spotting station in sequence. When plasma of the sample is to be filtered, a holder 16 with a filter is mounted on the sample container 10 set in the sample cartridge 7 as shown in Figure 1.

The dry analysis element 11 generally comprises a square mount and a reagent layer provided in the mount. A spotting

15   hole is formed on the surface of the mount and the sample is spotted in the spotting hole. The dry analysis element 11 is provided with bar codes (not shown) representing information on the item to be analyzed.

20   The spotting station (not shown) is for spotting a sample such as plasma, whole blood, serum, urine or the like on the dry analysis element 11. Though not shown, a bar code reader for reading the bar code on the element 11 is provided on the upstream side of the spotting station. The bar code reader

25   is for identifying the item of measurement and controlling the subsequent spotting and measurement, and for detecting the

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position of the element 11 (whether the element 11 is upside down or in a wrong direction).

The spotting nozzle unit 5 comprises a horizontal movement block 51 which is movable in a horizontal direction and a pair of vertical movement blocks 52 which are movable up and down on the horizontal movement block 51. A spotting nozzle 53 is fixed on each of the vertical movement block 52. The horizontal movement block 51 and the vertical movement blocks 52 are moved in the respective direction by drive means (not shown). The spotting nozzles 53 are integrally moved right and left and are moved up and down independently of each other. For example, one of the spotting nozzles 53 is for spotting the sample, and the other is for spotting the diluent.

The spotting nozzle 53 is in the form of a rod provided with an air passage extending in the axial direction and a pipette-like nozzle tip 12 is fitted on the lower end portion thereof. The spotting nozzles 53 are connected to air tubes respectively connected to syringe pumps (not shown), and a suction force and a discharge force are selectively supplied to the spotting nozzles 53. After measurement, the used nozzle tips 12 are removed from the spotting nozzles 53 and discarded.

The blood filtering unit 6 is inserted into the sample container 10 held in the sample tray 2 and sucks plasma through the holder 16 with a glass fiber filter which is mounted on the upper end of the sample container 10, thereby separating plasma from the blood and holding the separated plasma in a

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cup formed on the top of the holder 16.  The blood filtering

unit 6 comprises a sucking mechanism 61 which supplies suction

force, and a suction pad 62 which is connected to a suction

pump (not shown) and attracts the holder 16 under a suction

5     force is provided on the lower end of the sucking mechanism

61.  The sucking mechanism 61 is mounted on a support post 63

to be moved up and down by a drive mechanism (not shown).  When

the plasma is separated from the blood, the sucking mechanism

61 is moved downward to be brought into a close contact with

10    the holder 16.  In this state, the suction pump is operated

to suck the whole blood in the sample container 10, whereby

the plasma separated from the blood is introduced into the cup

formed on the top of the holder 16.  Thereafter, the sucking

mechanism 61 is returned to the initial position.

15         In Figure 1, a control panel 18 is provided above the

incubator 3.  The sample tray 2 and the spotting nozzle unit

5 are covered with a transparent protective lid 19 which is

openable.

           Operation of the biochemical analysis system 1 will be

20    described, hereinbelow.  A sample container 10 and one or more

unsealed dry analysis elements 11 suitable for the item of

measurement are set in a sample cartridge 7 outside the system

body 17.  Then the lid 19 is opened and the sample cartridge

7 is set in the sample tray 2.  When a plurality of samples

25    are to be measured, a plurality of suitable sample cartridges

7 are set in the sample tray 2.  Further consumables such as

the nozzle tips 12, the mixing cups 13, the diluent containers 14 and the like are set in the sample tray 2.

Then analysis is started.   In case of emergency, analysis is interrupted and the sample cartridge 7 to be analyzed urgently
5   is set in a vacant space or in place of another sample cartridge.

Blood plasma is first separated from the whole blood in the sample container 10 by the blood filtering unit 6.  Then the sample tray 2 is rotated to bring the sample cartridge 7 containing therein a sample to be analyzed to the spotting
10   station.  Then one of the dry analysis elements 11 in the sample cartridge 7 is transferred to the spotting station by the element transfer member 91 of the transfer means 9.  On the way to the spotting station, the bar code on the element 11 is read by the bar code reader and the item of analysis and the like are
15   detected.

When the item of analysis represented by the bar code is colorimetry, the sample tray 2 is rotated to bring a nozzle tip 12 below the spotting nozzle 53 and the nozzle tip 12 is mounted on the spotting nozzle 53.  Then the sample container
20   10 is moved and the spotting nozzle 53 is moved downward to dip the nozzle tip 12 into the sample and to cause the nozzle tip 12 to suck the sample.  Thereafter the spotting nozzle 53 is moved to the spotting station and spots the sample onto the dry analysis element 11 at the spotting station.

25   Then the dry analysis element 11 spotted with the sample is inserted into an element chamber 33 of the incubator 3.  In

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response to insertion of the dry analysis element 11 into the element chamber 33, the pressing member 34 presses downward the dry analysis element 11, whereby evaporation of the sample is prevented and the dry analysis element 11 is heated to a

5    predetermined temperature. After insertion of the dry analysis element 11 into the element chamber 33, the incubator rotor 30 is rotated to bring the element chambers 33 to the measuring position in sequence where the dry analysis element 11 in the chamber 33 is opposed to the light measuring head 41. After

10   a predetermined time, change of the optical density of the element 11 due to reaction of the sample with the reagent is measured by the light measuring head 41. After the measurement, the dry analysis element 11 is pushed toward the center by the element transfer member 91 to be discarded. The result of the

15   measurement is output and the used nozzle tip 12 is removed from the spotting nozzle 53. Then processing is ended.

When the sample is to be diluted, e.g., when the blood is too thick to carry out accurate measurement, the sample tray 2 is moved to bring the nozzle tip 12 holding the sample to

20   a mixing cup 13. Then the spotting nozzle 53 discharges the sample held by the nozzle tip 12 into the mixing cup 13. Then the used nozzle tip 12 is removed from the spotting nozzle 53, and a new nozzle tip 12 is mounted on the spotting nozzle 53. The spotting nozzle 53 causes the nozzle tip 12 to suck the

25   diluent from the diluent container 14 and to discharge the diluent into the mixing cup 13. Thereafter the spotting nozzle

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53 dips the nozzle tip 12 into the mixing cup and causes the nozzle tip 12 to repeat suck and discharge, thereby stirring the mixture in the mixing cup 13. Then the spotting nozzle 53 causes the nozzle tip 12 to suck the diluted sample and moves the nozzle tip 12 to the spotting station. At the spotting station, the spotting nozzle 53 causes the nozzle tip 12 to spot the diluted sample onto the dry analysis element 11. Then the aforesaid, light measuring step, element discarding step and result outputting step follow.

In the incubator of this embodiment, since the measured optical density output by the light measuring head 41 is corrected according to the position of the element chamber 33, that is, the distance to the light measuring head 41 of the element chamber 33, fluctuation of the distance between the light measuring head 41 and the element chamber 33 due to errors and/or strain in processing and/or assembly can be compensated for, and accordingly, the optical density of the dry analysis element 11 can be accurately measured without adding to the manufacturing cost of the incubator.

Figure 6 is a cross-sectional view showing an incubator in accordance with another embodiment of the present invention. The elements analogous to those shown in Figures 1 and 2 are given the same reference numerals and will not be described in detail here.

The incubator 103 of this embodiment comprises an incubator rotor 30 and a measuring means 4. The incubator rotor

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30 comprises lower and upper disc members 31 and 32, and a plurality of element chambers 33 in which the dry analysis elements 11 are inserted are formed between the lower and upper disc members 31 and 32 arranged along the circumference of the disc members 31 and 32 at regular intervals. The bottom surface of each element chamber 33 is flush with the upper surface of the spotting station and the dry analysis element 11 can be inserted into the chamber 33 from the spotting station by simply pushing the element 11.

Sliding holes 32a are formed in the upper disc member 32 to be opposed to the element chambers 33. A pressing member 34 is disposed above each element chamber 33 with its upper portion slidably received in the sliding hole 32a. The lower surface of the pressing member 34 presses downward the dry analysis element 11 inserted into the element chamber 33 and tightly closes the spotting hole of the dry analysis element 11 (through which the sample is spotted onto the element 11) to prevent evaporation thereof. The outer edge of the lower portion of the pressing member 34 is tapered so that the dry analysis element 11 inserted into the element chamber 33 is brought into abutment against the tapered surface to push upward the pressing member 34.

A heater 35 is provided in the upper disc member 32 to heat the dry analysis elements 11 in the element chambers 33. By controlling the heater 36, the dry analysis elements can be held at a desired constant temperature (incubated).

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A light measuring window 31a is formed in the bottom of the lower disc member 31 opposed to each of the element chambers 33. A light measuring head 41 is positioned below the light measuring window 31a of the element chamber 33 stopped in a light measuring position shown in Figure 2. A circular opening 108a which opens in the element discarding hole to be described later is formed in the central portion of the lower disc member 31. A lower member 136 is provided below the circular opening 108a.

The lower member 136 is provided with a cone-like slant surface 136a which tapers downward toward the axis of rotation of the incubator rotor 30, a cylindrical rotating shaft 136b which is connected to the lower end of the slant surface 136a and the inner space of which opens to the space defined by the cone-like slant surface 136a so that the dry analysis element in each element chamber can be discarded outside the incubator 3 through the space defined by the cone-like slant surface 136a and the inner space of the cylindrical rotating shaft 136b.

A bearing member 137 horizontally supports the cylindrical rotating shaft 136b for rotation about the axis of rotation of the incubator rotor 30. When the slant surface 136a is at an angle not smaller than 30° to the horizontal, the dry analysis element 11 is surely slid on the slant surface 136a toward the cylindrical rotating shaft 136b.

In the incubator of this arrangement, the rotating shaft 136b need not be large in diameter even if the number of the

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dry analysis elements 11 to be accommodated in the incubator 3 increases and the diameter of the incubator rotor 30 increases, and accordingly, the bearing member 137 may be small in diameter, whereby the incubator 3 can be manufactured at low cost. Further, since the dry analysis elements 11 after measurement can be discarded by pushing the dry analysis elements 11 only to the slant surface 136a, the stroke of the element transfer member need not be enlarged even if the number of the dry analysis elements 11 to be accommodated in the incubator 3 increases and the diameter of the incubator rotor 30 increases, whereby the incubator 3 can be small in size and weight.

Further by virtue of the lower member 136 defining the cone-like slant surface 136a, rigidity of the incubator rotor 30 is increased and the incubator rotor 30 can be rigid enough though it is small in weight, whereby wobbling of the incubator rotor 30 can be suppressed without use of a sliding support and the measuring accuracy can be enhanced.